Letters to the Editor

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NOTES ON POINTS IN SOME OF THIS WEEK'S LETTERS APPEAR ON P. 646.

CORRESPONDENTS ARE INVITED TO ATTACH SIMILAR SUMMARIES TO THEIR COMMUNICATIONS.

Diffraction of Light by Ultra-Sonic Waves

F. H. SANDERS[1], in a recent note in these columns, has reported excellent agreement between our theory and his experimental results. His note, however, calls for a statement from us clarifying the theoretical position. As is well known, Debye and Sears in America and Lucas and Biquard in France discovered, in 1932, that a beam of light after passing through a supersonic field breaks up into a fan of diffraction spectra. Following this discovery, Prof. R. Bär, of Zurich, carried out extensive investigations regarding the nature of the phenomenon ; he obtained numerous beautiful results concerning the manner in which the relative intensities of the various diffraction spectra depend on the wave-length of light, the supersonic intensity and the thickness of the cell. He also discovered that the frequencies of light in the diffracted spectra are modulated by the sound field in a very peculiar manner depending on the order of the spectrum.

As has been remarked by many investigators, these results of Bär, and even the appearance of a large number of diffraction spectra, found no explanation in terms of the theory of Brillouin. Indeed, the existence of higher orders had been erroneously ascribed to the existence of overtones in the supersonic field. In the theory of Lucas and Biquard, which was mentioned by Sanders in his note, the laws of geometrical optics were applied to the problem, and it was assumed that the individual rays of the incident light follow paths independent of one another. This theory ignores the interference effects which are fundamental to the problem, and does not succeed in explaining the characteristic features observed in experiment.

The theory of the phenomenon initiated by us is set out in a series of papers[2]. At the outset, our purpose was to develop a theory of the simplest possible character which would satisfactorily account for Bär's experimental results. A simplification was effected by assuming that the wave-length of the sound is not too small and the thickness of the cell is not too large; in which circumstances, it can be shown theoretically from Fermat's principle that only the phase changes occurring in the passage of light through the cell need be considered. Indeed, Bär[3] reported later that the results in our papers I, II and III agreed qualitatively with most of the observed features of the phenomenon even in the general case, and in a perfectly quantitative manner when the experimental restrictions postulated by us were actually satisfied. In our papers IV and V, the restrictions mentioned above were dispensed with and the theory of the phenomenon was developed quite figorously on the basis of the electromagnetic wave-equations. This general theory has been fully worked out by one of us (N. S. N.) and leads to a satisfactory explanation of some remarkable experimental results obtained by Dr. S. Parthasarathy[4] at this Institute. It is found that, when the light is incident obliquely to the sound waves and the latter are of sufficiently high frequency, the intensity of the diffraction spectra shows very marked asymmetry and that particular orders attain maximum intensity at characteristic angles of incidence given by a formula of the Bragg type. This is in agreement with the deductions from the theory.

Another aspect of the problem has been worked out by one of us (N. S. N.) in a paper now under publication. It has been explained why the supersonic waves can be seen directly through a microscope focused on a plane to the rear of the sound-wave cell. The theory predicts the interesting result that the grating-like pattern observed through the microscope repeats itself periodically as the focal plane of the microscope is moved away from the cell by integral multiples of a definite distance. This prediction has been confirmed quantitatively in a very recent (as yet unpublished) investigation made at this Institute by Dr. Parthasarathy. Other peculiar features of the sound field as optically observed—for example, a doubling of the number of fringes in certain positions of the microscope, and a disappearance of the fringes at certain other positions—are also indicated by the theory and are beautifully confirmed by the experiments.

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Sept. 9.

[1] F. H. Sanders, NATURE, **138**, 285 (1936).

[2] C. V. Raman and N. S. Nagendra Nath, *Proc. Ind. Acad. Sci.*, **2**, 406 and 413 (1935); **3**, 75, 119 and 459 (1936). N. S. Nagendra Nath, *Proc. Ind. Acad. Sci.*, **4**, 222 (1936).

[3] R. Bär, *Helv. Phy. Acta*, **9**, 265 (1936).

[4] S. Parthasarathy, *Proc. Ind. Acad. Sci.*, **3**, 549 (1936).

Surface Markings on a Diamond

ACCORDING to the mosaic hypothesis, it is postulated that the uniform lattice structure of an ideal crystal is interrupted over narrow regions distributed periodically throughout the crystal at distances large compared with the size of the unit cell. Various forms of the hypothesis have been devised to explain anomalies in the intensity of reflection of X-rays, breaking strength and other 'structure-sensitive' properties of crystals, but the subject is at present highly controversial. Whilst many facts undoubtedly fit the hypothesis, several workers claim that some half dozen other types of fact do not fit[1]. All forms of the hypothesis including the 'lineage structure' proposed by Buerger[2] would predict non-uniformity

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on such a section of a crystal as a crystal face. Hence all observations of small-scale regular markings such as etch figures and slip bands at the crystal surface and especially their minimum dimensions are highly relevant to the subject.

The dimensions of the sharply defined triangular markings shown in numerous photomicrographs[3] of natural (111) faces of diamond are all large compared with the hypothetical dimensions, about 1 μ, of mosaic irregularities. Whilst examining the surface irregularities on some unusually good specimens kindly lent by Prof. W. T. Gordon for X-ray study, it was noticed that a number of regions on one specimen which at ordinary powers of magnification appeared to be free from triangular markings, at magnifications of about 750 diameters showed many minute triangles (Fig. 1). Their orientation was normal, with the angles pointing towards octahedron edges, and the edge of the smallest clearly resolved triangle measured 1·3 μ.

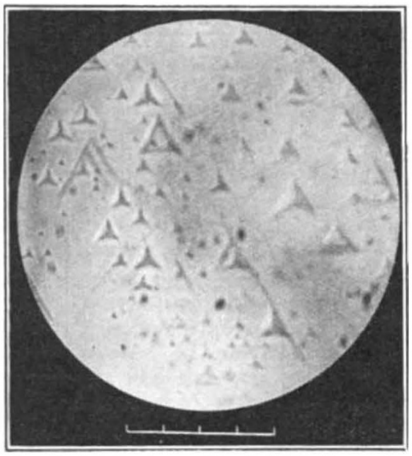

FIG. 1. Photomicrograph of (111) face of a diamond showing some triangular markings of 'mosaic' dimensions. Each scale division represents 0·01 mm.

These abnormally small regular markings were found only in groups and only at the edges of the crystal face. They were not detected on any of the other specimens examined similarly. The specimen measuring about 6 mm. × 4 mm. was the only one from the new diamond field at Sierra Leone. No trace of striations of this 'mosaic' order of magnitude was detected optically, but even the triangular markings themselves were difficult to observe because of their minuteness and the high transparency of the diamond. The optical difficulties were too great to justify an attempt to find the unit size of the largest equilateral triangular network fitting *all* the observed triangles[4]. For the (111) face of bismuth this derived quantity, claimed to be of the order 1·4 μ, is about the same as the observed dimensions of the edge of the smallest triangle on the diamond. Sufficient contrast to see or to photograph the markings was got by defocusing, and I am indebted to Mr. G. A. de Belin for the trouble taken to get the photomicrograph reproduced.

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[1] See Ann. Report Chem. Soc., 189 (1935).

[2] Buerger, *Z. Krist.*, **89**, 195 (1934).

[3] A. F. Williams, "The Genesis of the Diamond", vol. 2 (1932); and J. R. Sutton, "Diamond" (1928).

[4] Goetz, *Proc. Nat. Acad. Sci.*, **16**, 99 (1930).

Optical Experiments on Liquid Helium II

THE anomaly in the specific heat of liquid helium at 2·19° K. has the same shape as that of the λ-point anomaly in crystalline substances. In crystalline bodies the λ-point anomaly, similar to that shown by ferromagnetic bodies at the Curie point, is due to some process connected with a change of order in the crystal.

It is natural to suppose that in the case of liquid helium II we also have to do with some form of order. As this type of transition is observed in liquids when liquid crystals are formed, it is not impossible that liquid helium at temperatures below 2·19° K. also forms liquid crystals.

Liquid crystals are anisotropic, and it is therefore interesting to study the optical properties of liquid helium II. If liquid helium II does in fact form liquid crystals, polarized light, on passing through a layer of helium, must be depolarized, as on its way it traverses a large number of optically anisotropic regions of different orientation.

In our experiments a layer of helium, 10 cm. in length, was placed between crossed nicols. The accuracy was such that a change in the intensity of light corresponding to a rotation of the prisms of ± 1·5° could easily be registered. On cooling the helium from 4·22° to 1·72° K. no change in the intensity of the light could be detected. It is possible that the effect could not be observed owing to the small dimensions of the liquid crystals. We therefore studied the Kerr effect in liquid helium II at 1·72° K. in a constant field of 63,000 volts per cm. No change in the light intensity could be observed with crossed nicols, the planes of polarization of which formed an angle of 45° with the direction of the electric field.

Assuming that the field was sufficiently strong completely to orient the optical axes of the crystals, we have computed that the anisotropy of the refractive index for helium II is less than 7×10^{-8}. If the optical axes were oriented perpendicularly to the direction of the field, this ratio would be 1×10^{-7}.

As the optical anisotropy which might have been expected in helium II lies within the accuracy of measurement, it must be assumed that the anomaly in liquid helium cannot be explained by a transition into the liquid crystal state.

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Infra-red Absorption Spectrum of Heavy Phosphine (PD_3)

THE infra-red absorption spectrum of PD_3 has been investigated with the view of testing the applicability of the 'valence force field' in correlating the fundamental vibration frequencies of a pyramidal molecule of the type YX_3. If it is assumed that the valence force field applies to PH_3, then one can deduce the values of the force constants of this molecule from its known vibration frequencies. This has been done by Howard[1], who gives $3{\cdot}09 \times 10^5$ dynes/cm. for the force required to alter the PH distance, and $0{\cdot}34 \times 10^5$ dynes/cm. for that required to alter the HPH angle. From these data one may compute the frequencies of the PD_3 molecule (since it is permissible to assume that these force constants are not appreciably altered by the substitution of a